

GENI: Global Environment for Networking Innovations

To Reinvent the Internet

**Guru Parulkar
CISE/NSF
gparulka@nsf.gov**



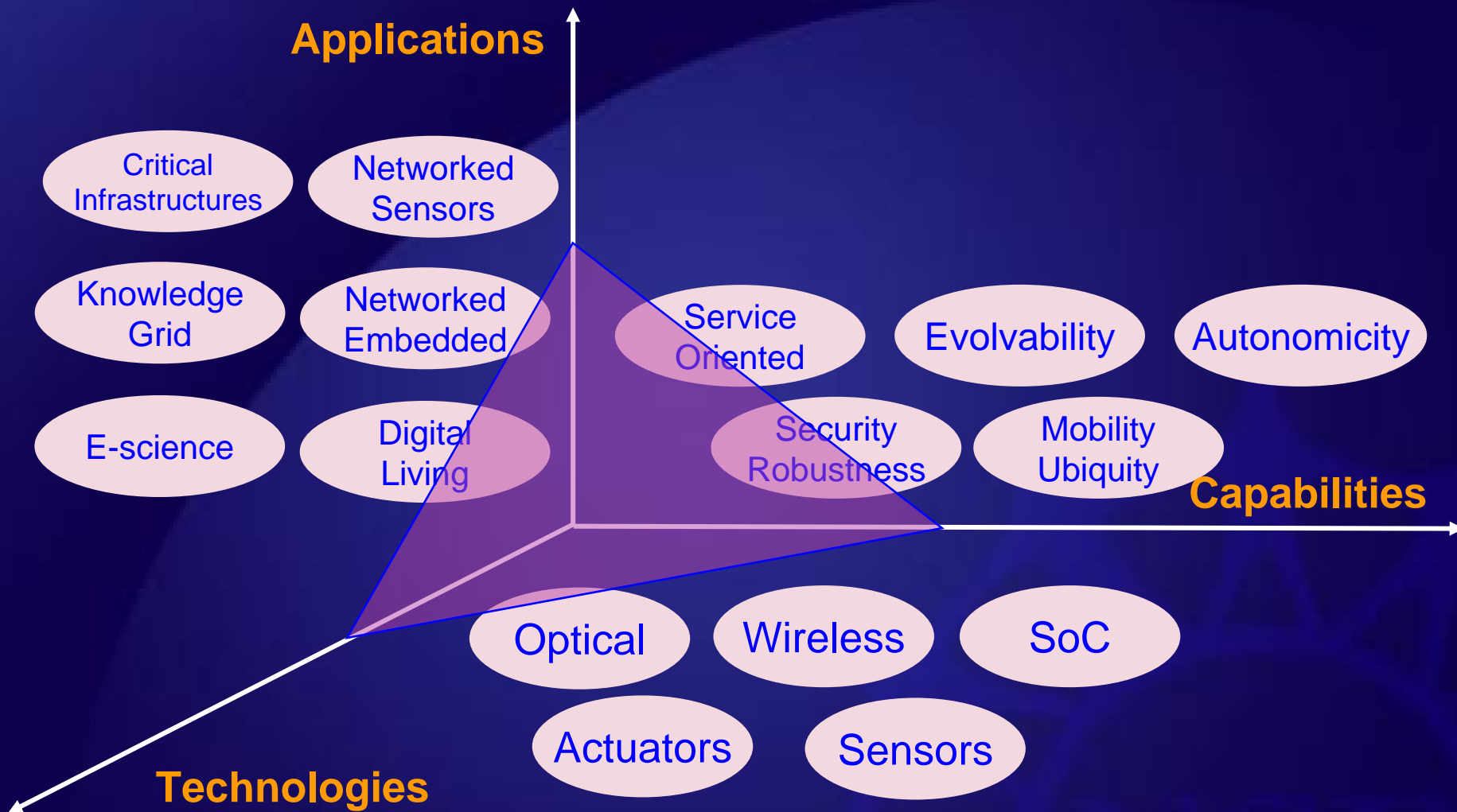
State of Internet

“... in the thirty-odd years since its invention, new uses and abuses, ..., are pushing the Internet into realms that its original design neither anticipated nor easily accommodates.”

“Freezing forevermore the current architecture would be bad enough, but in fact the situation is deteriorating. These architectural barnacles—unsightly outcroppings that have affixed themselves to an unmoving architecture— may serve a valuable short-term purpose, but significantly impair the long-term flexibility, reliability, security, and manageability of the Internet.”



Looking Ahead





Future Internet?

Distributed Systems and Services?

Network and Protocol Architectures?

New Paradigms?

Applications &
User
Requirements

Enabling
Technologies

Network
Capabilities

Internet
Arch Limitations
Erosion

Need a clean-slate approach



GENI Initiative: Goals

- Invent innovative internet architectures and distributed system capabilities -- go beyond Internet
- Enable seamless conception-to-deployment process
 - A large scale experimentation facility



GENI: Example Research Goals

**Security and
Robustness**

**Pervasive
Computing w
Mobility**

**Bridging
Physical and
Cyber space**

**Realize
Potential of
Opto-
Electronics**

GENI

Capability:
Information
Access with
High
Availability
& Trust

Capability:
Seamless
information
access any
where and any
time

Capability:
Access
information
about physical
world in real
time

Capability:
Access to
Bandwidth-on-
Demand with
low latency &
guarantees



Focus of GENI

Applications

Applications

Applications

Applications

Future Internet

(Broadly Defined: E2E Networking and Distributed Systems)

Backbones

Combination of
All optical transport and
Packet service networks

Campus/Access
Backbone

Campus/Access
Backbone

Edge Networks

Edge Networks

Wireless WiMax, multi-hop 802.11[a,g], cellular, SDRs
Wired: Ethernet, DSL, Cable
Optical: Ethernet over SONET over CWDM, all optical,

Wireless Technologies: Bluetooth, Zigbee, 802.11[a,b,g], SDRs
Wired: All kinds of Ethernet, cable, power line
Optical: Optical Ethernet (non WDM), WDM, all optical



GENI: Research Programs

Broad but goal oriented programs

| | |
|------------|--|
| NeTS | FIND: Future Internet Design |
| CyberTrust | Clean-slate secured network arch |
| CSR | New distributed system capabilities |
| CCF | SING |
| CRI | Network infrastructure for arch research |
| MRI | Network instruments for arch research |
| ... | ... |



Network Architecture Ideas

- Network virtualization
- Architecture with middle boxes
 - network embedded computing and storage
- Naming and addressing architectures
 - Digital objected oriented architectures
- Architectures with sub-networks with dynamic topologies
 - Dynamic optical networks
 - Cognitive radios



Network Architecture Ideas

- Architectures with location awareness support
- Management plane
 - Management of routing systems
- Measurement & instrumentation infrastructure
- Clean-slate secured network architecture
- Universal protocol

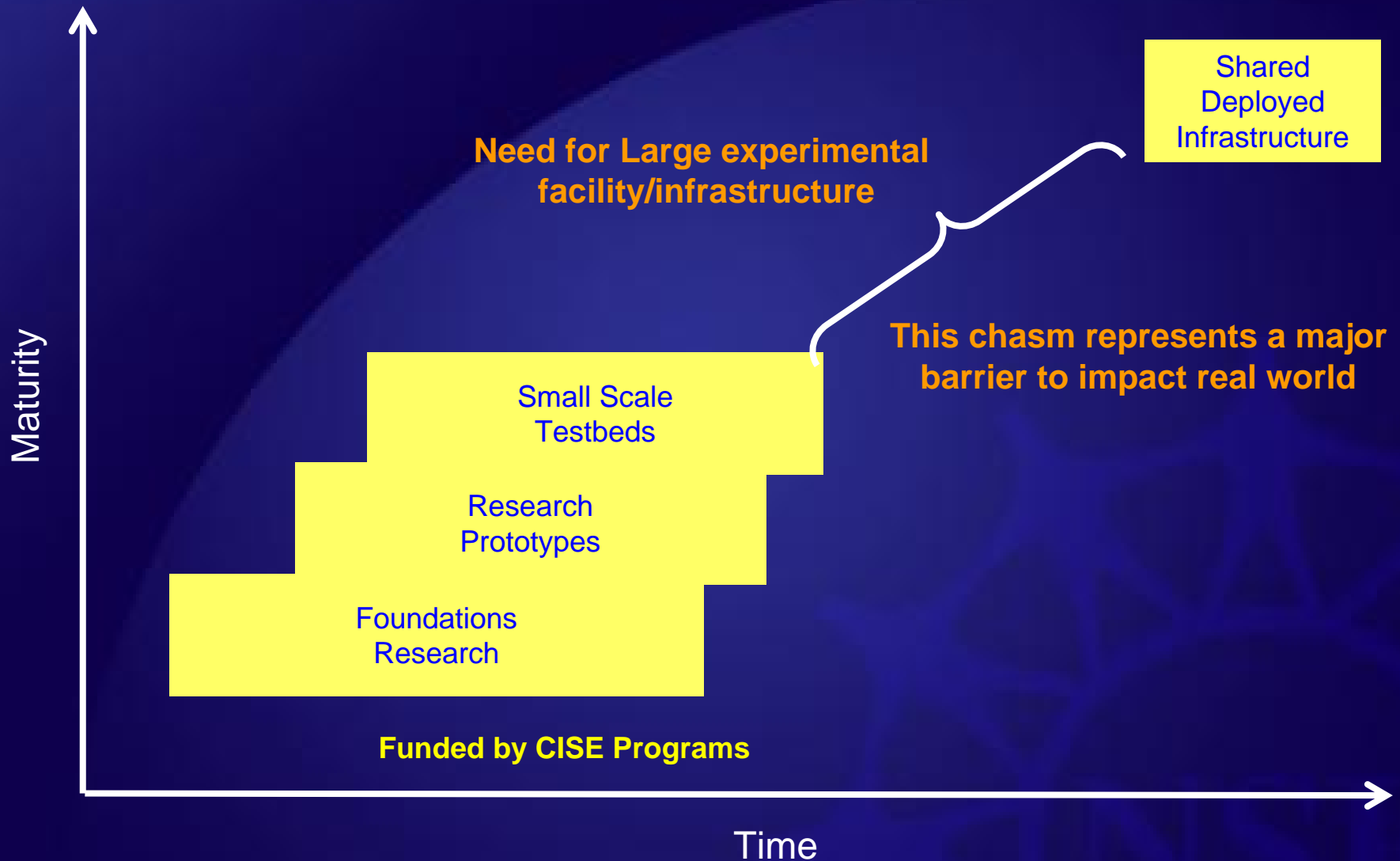


Distributed Systems Substrate

- Robust content distribution
 - Naming, security, resilience
- Management and sharing of personal information
- Real time multi-media distribution
- Network-embedded storage
- Location management: human and object
- Identity management: human and object



Case for GENI Facility





Facility Goals

Enable exploration of new network architectures, mechanisms, and distributed system capabilities

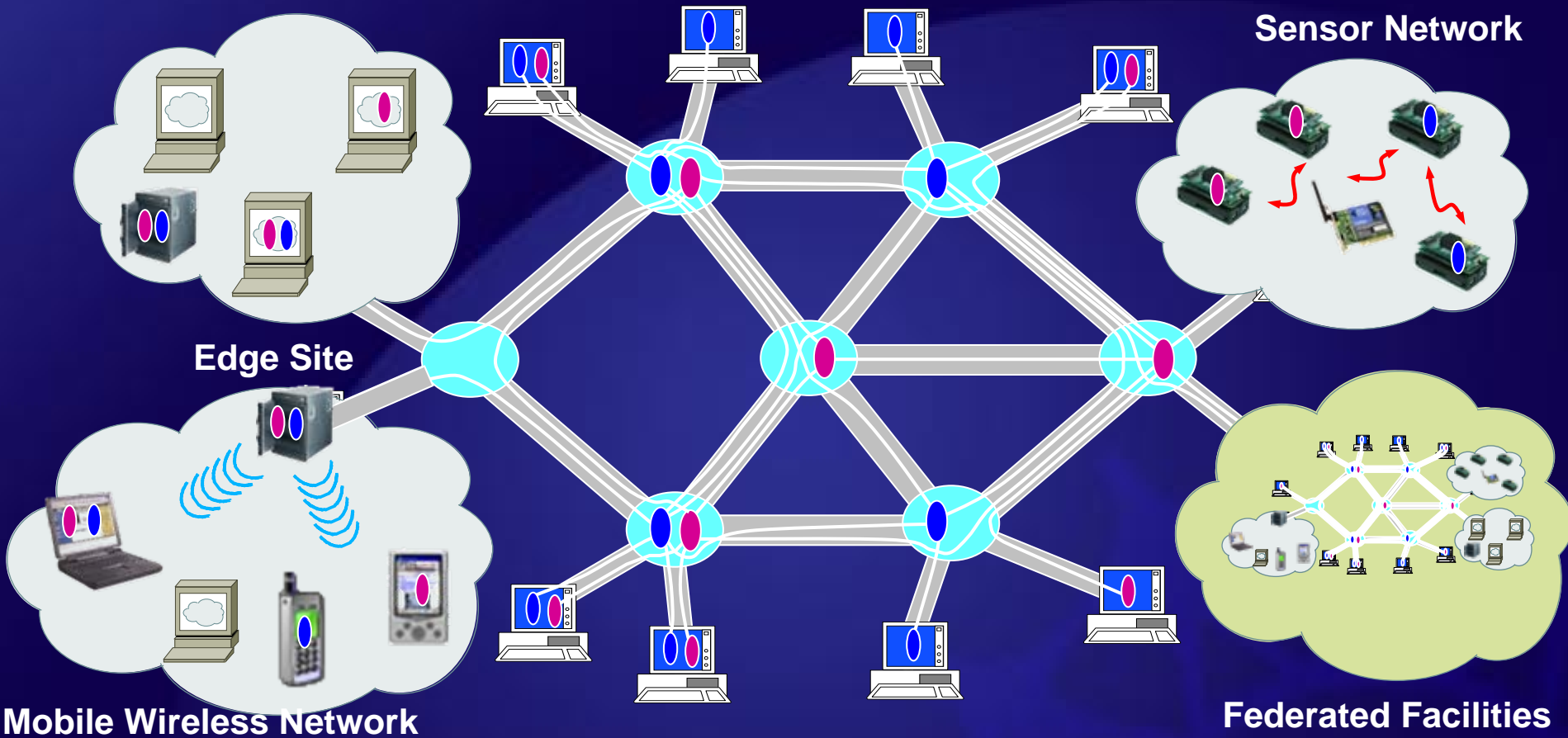
A shared facility that allows

- Concurrent exploration of a broad range of experimental networks and distributed services
- Interconnection among experimental networks & the commodity Internet
- Users and applications able to “opt-in”
- Observation, measurement, and recording of outcomes

Help develop stronger scientific base



Facility Design: Key Concepts



Slicing, Virtualization, Programmability



Scope of Research & Experiments

Applications

Applications

Applications

Applications

Service A

Distributed Systems and Services

Dist Sys X

Dist Sys Y

Dist Sys Z

Service B

Service C

Arch A

E2E Architectures and Components

Arch Comp
X

Arch Comp
Y

Arch Comp
Z

Arch B

Arch C

GENI Facility Substrate: Sharable Physical Infrastructure

Backbones

Campus/Access
Backbone

Campus/Access
Backbone

Combination of All optical transport and
Packet service networks

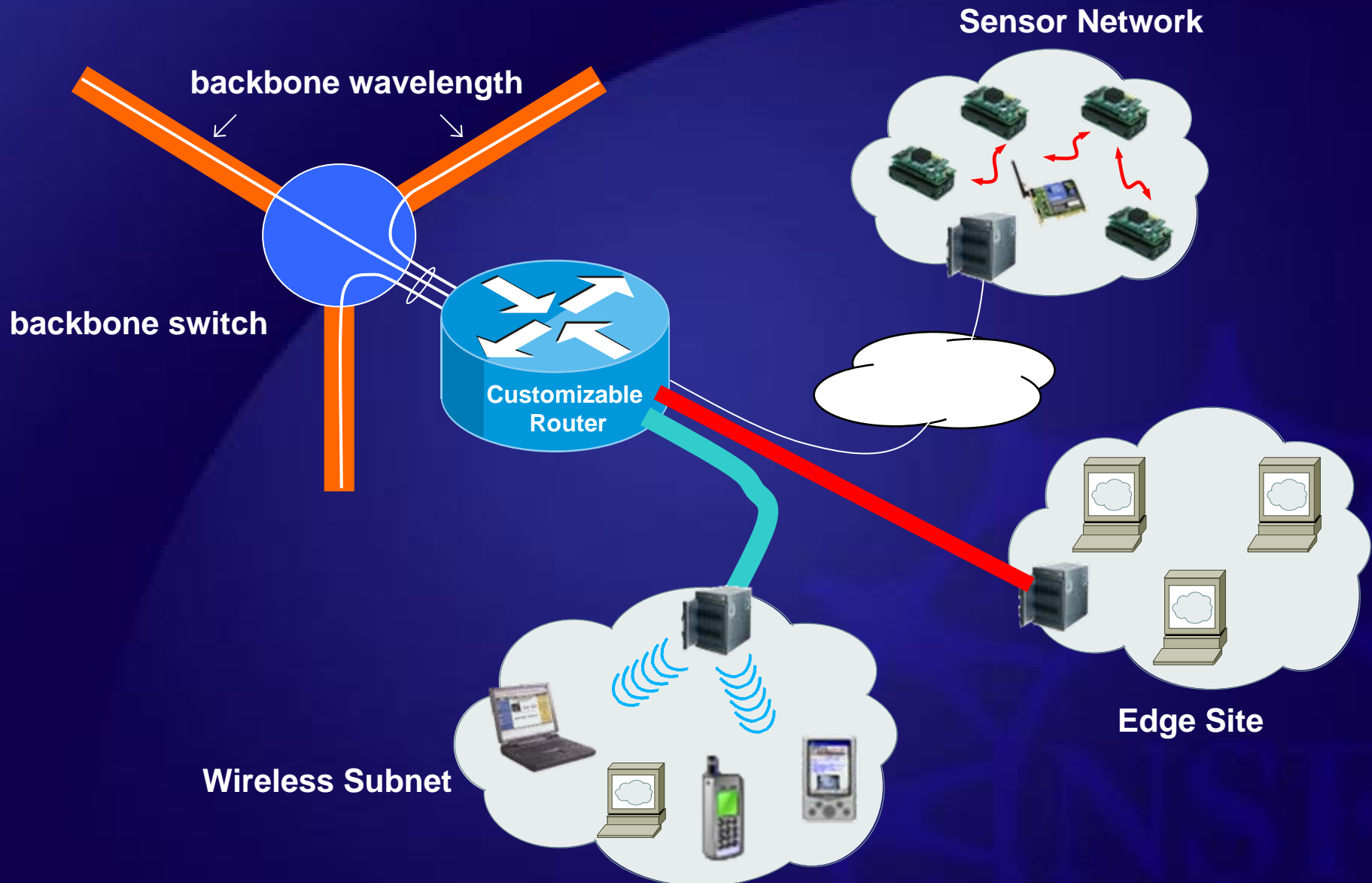
Edge Networks

Numerous Wired, Mobile Wireless, and Sensor Networks

Edge Networks

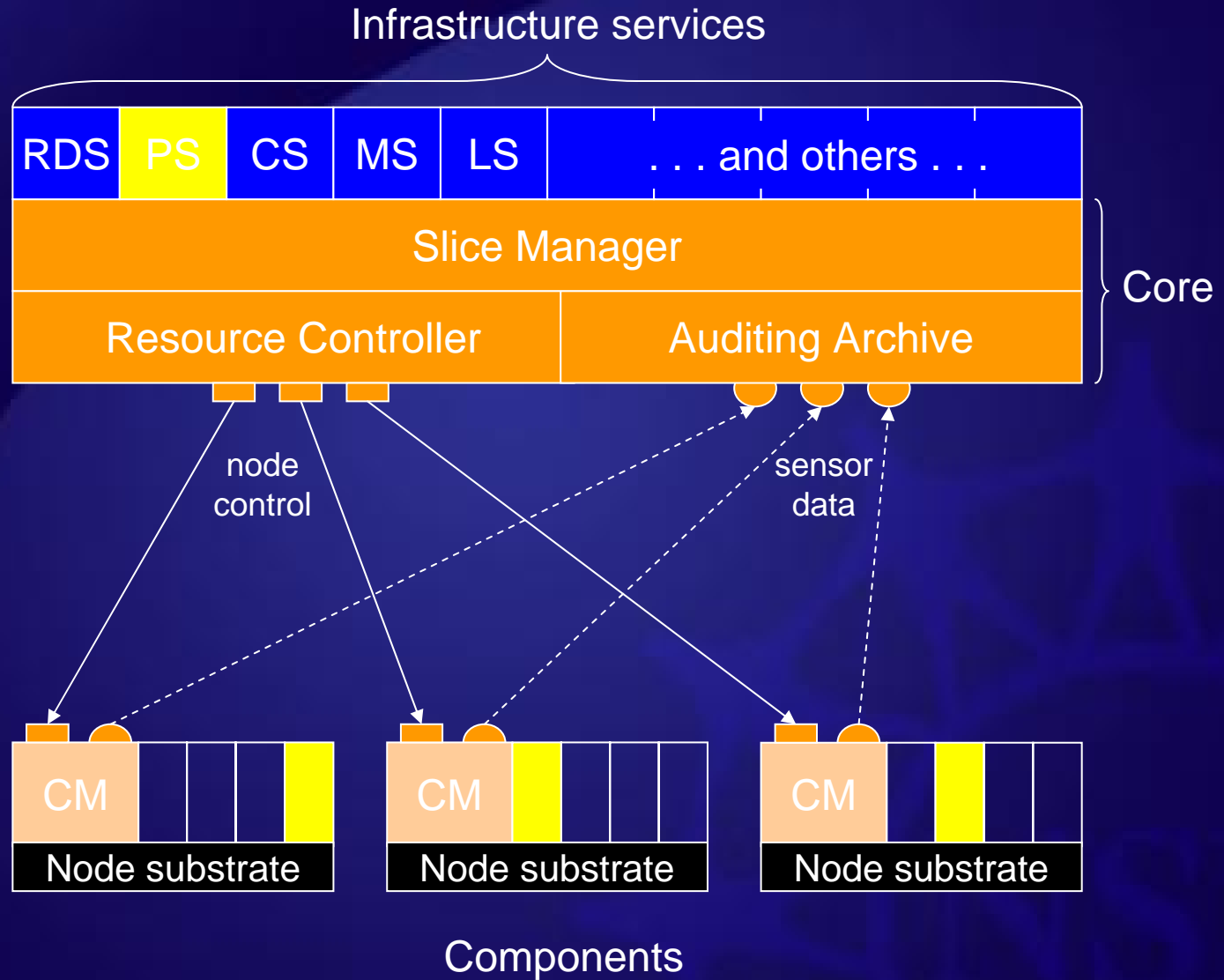


Details of the Facility





Facility Architecture: How do Parts Fit Together?





GENI and Optical Networking

- Optical network substrate to provide
 - Dynamic circuits on demand
 - Sub-wavelength as well as wavelength granularity
 - Reconfiguration times sub-second
 - Point to point as well as complex topologies
- Enable research on data, control, and management planes of such optical networks
- Higher level architectures to exploit these capabilities for Future Internet architectures

Optical Networking Research on GENI: Details



Acknowledgments

- The GENI Planning Group
 - Peterson, Anderson, Blumenthal, Casey, Clark, Estrin, Evans, Raychaudhuri, Reiter, Rexford, Shenker, Wroclawski
- The GENI Working Groups
 - Research Coordination
 - Facility Architecture
 - Distributed services
 - Backbone
 - Mobile wireless sensor networks
- Planning grant workshops participants
- CISE GENI Team
- And many others from the broader research community

www.nsf.gov/cise/geni/

www.geni.net



Summary

- Internet impacted the world in a way few inventions have
 - Federal agencies played a critical role in Internet's success
- Scientific foundation of future networking & distributed systems key
- Urgent and important need to reinvent the Internet
 - We have an opportunity and obligation to lead
- GENI a compelling initiative in support of this mission

**The result may be even greater and far-reaching
than the invention of current Internet**